National Renewable Energy Laboratory
Innovation for Our Energy Future

NREL's Plans & Strategies for Building Green Data Centers

2009 DOE Information Management Conference

Chuck Powers

March 2, 2009

What Makes NREL Unique?

- Only national laboratory dedicated to renewable energy and energy efficiency R&D
- Collaboration with industry and university partners is a hallmark
- Ability to link scientific discovery and product development to accelerate commercialization

Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

- Wind and water
- Solar
- Biomass
- Geothermal

Energy Delivery and Storage

- Electricity Transmission and Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage

Foundational Science and Advanced Analytics

Research Support Facility (RSF)

- LEED® Platinum "Plus"
- 220,000 sq. ft.
- Supports ~750 administrative staff
- Complete July 2010
- Contain NREL Data Center
- Model for new buildings

Research Support Facility (RSF)

Use of renewable / recycled energy

- 750kW PV array
- Renewable Fuels Heating Plant
- Waste heat from Data Center

Research Support Facility (RSF)

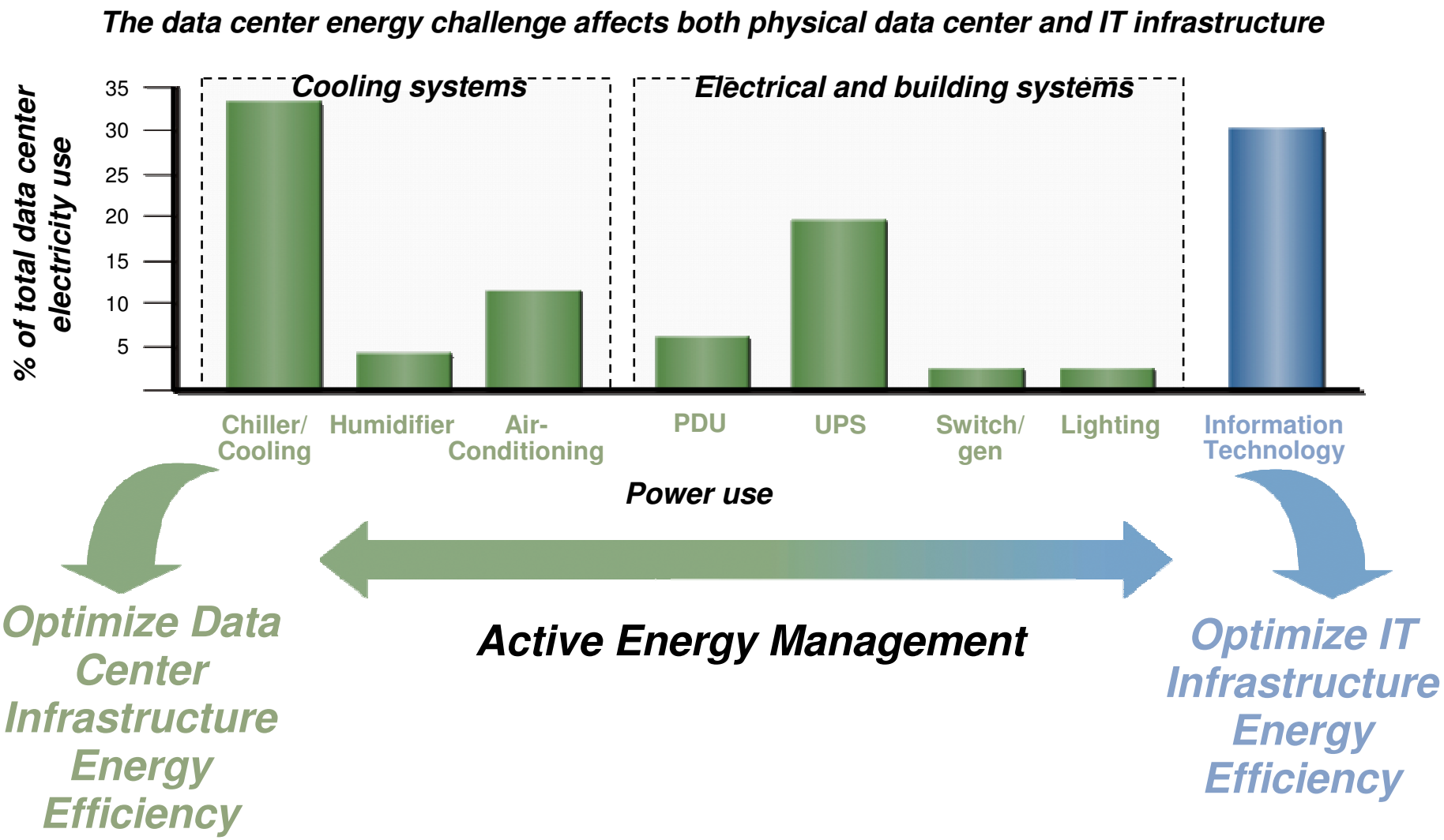
Energy efficiency

- Average DOE lab: 80.6kW / sq. ft./ yr.
- National average: 22kW
- Denver building code: 14.6kW
- Energy goal for RSF: 7.3kW / sq. ft./ yr.
- **1/10th of the DOE lab average!**

Why is Data Center Efficiency Important?

- Data centers are facing a power and cooling crisis
- Data centers use 2-3% of all power produced in the U.S.
- Data center power demands are increasing
- Energy costs expected to rise
- Energy costs expected to exceed equipment costs

Data Center Power Usage

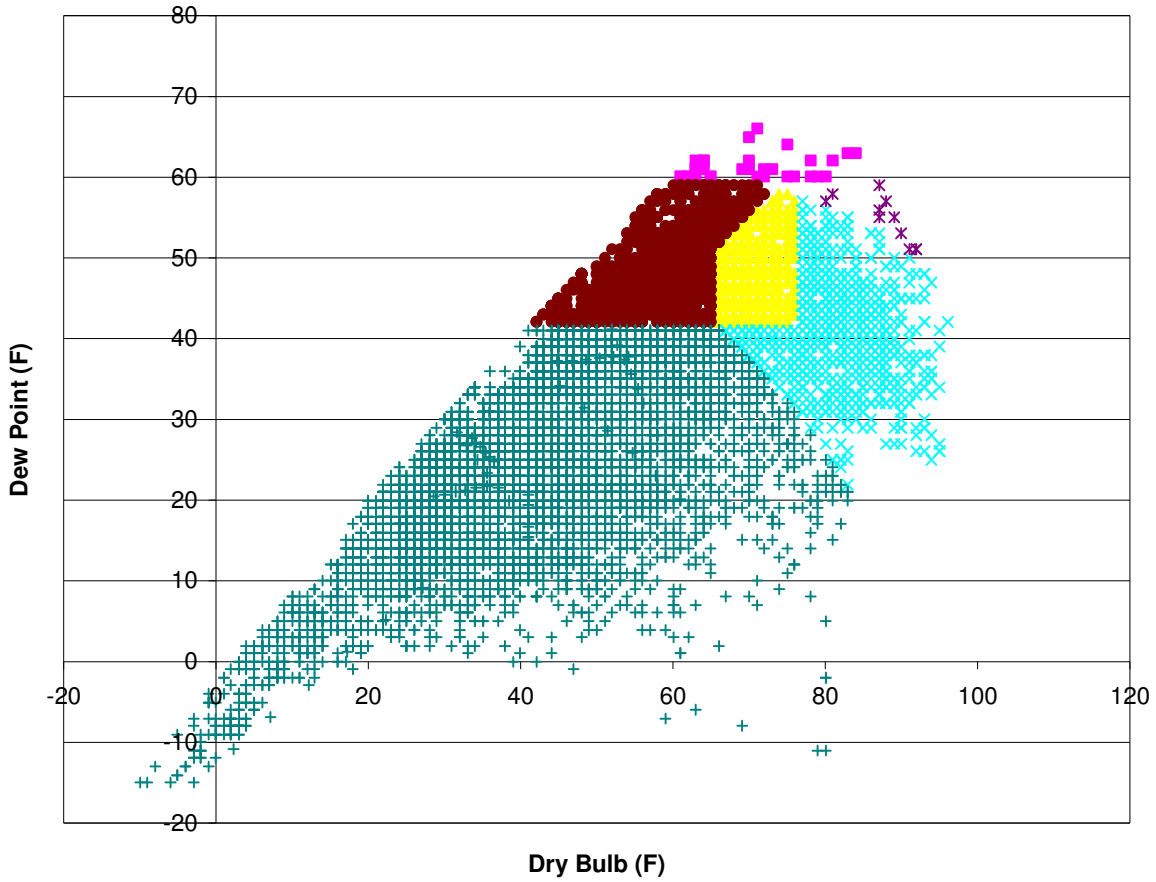


Source: Gartner

Power Usage Effectiveness (PUE)

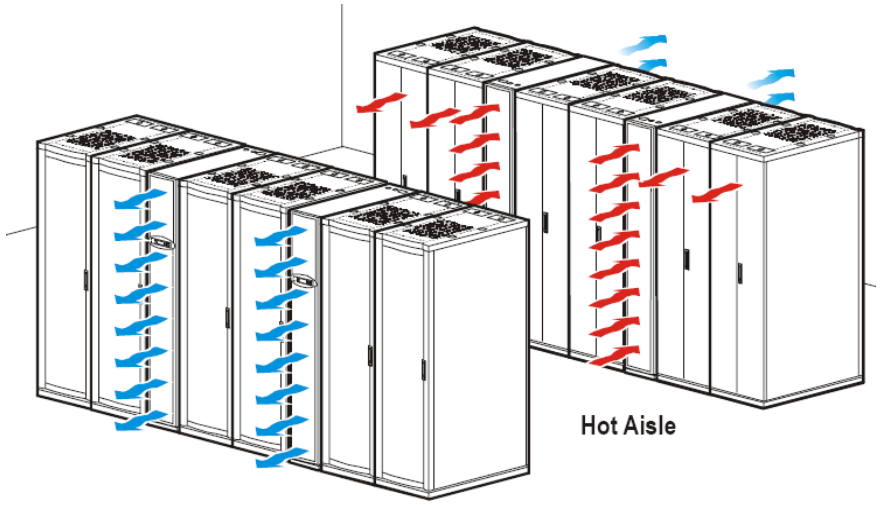
$$PUE = \frac{\text{Cooling} + \text{Power} + \text{Equipment}}{\text{Equipment}}$$

“Free Cooling”



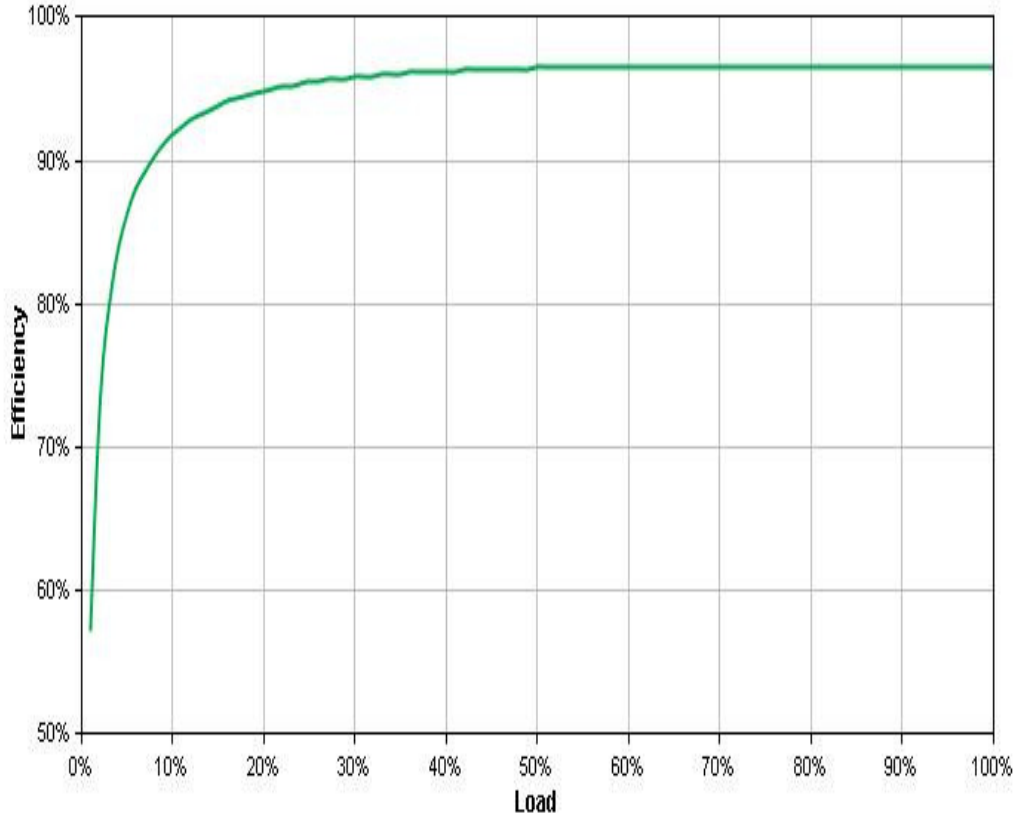
Cooling System

- Custom hybrid cooling system using air-side economizer, water-side economizer and chilled water
- Layout data center using hot and cold aisles
- Contain heat produced by equipment
- Waste heat will be use to supplement building heat



Uninterruptible Power Supply (UPS)

- 96% energy efficient
- Designed for scalability
- Provides 15 minutes of uptime
- Operate in efficiency “Sweet Spot”



Other Power Stuff

- Power Distribution Unit
  - 98.6% efficient
- Lighting
  - Energy efficient lights
  - Motion sensors
  - Day lighting

Power Usage Effectiveness (PUE)

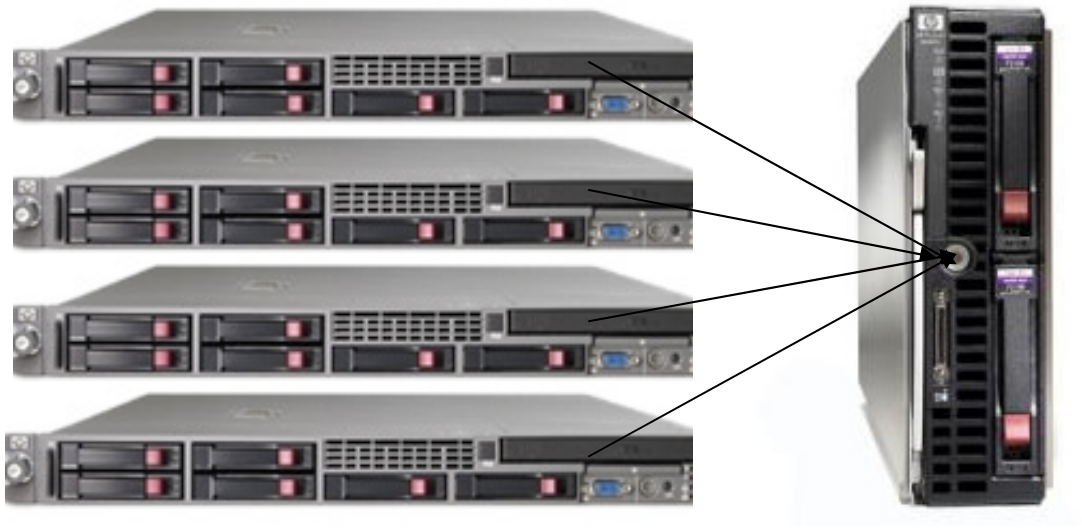
$$PUE = \frac{\text{Cooling} + \text{Power} + \text{Equipment}}{\text{Equipment}}$$

Servers

- Moving towards high-density blade servers
  - Highly efficient power supplies
  - Variable speed fans
  - Wake-on-LAN
- Server consolidation/virtualization
  - Ratio: 4-8 to 1
  - VMware for Windows & LINUX
  - Solaris Containers on Sun
- Increase server utilization
  - Nominal increase in energy consumption for a higher server utilization

Virtualization Effect on Power Footprint

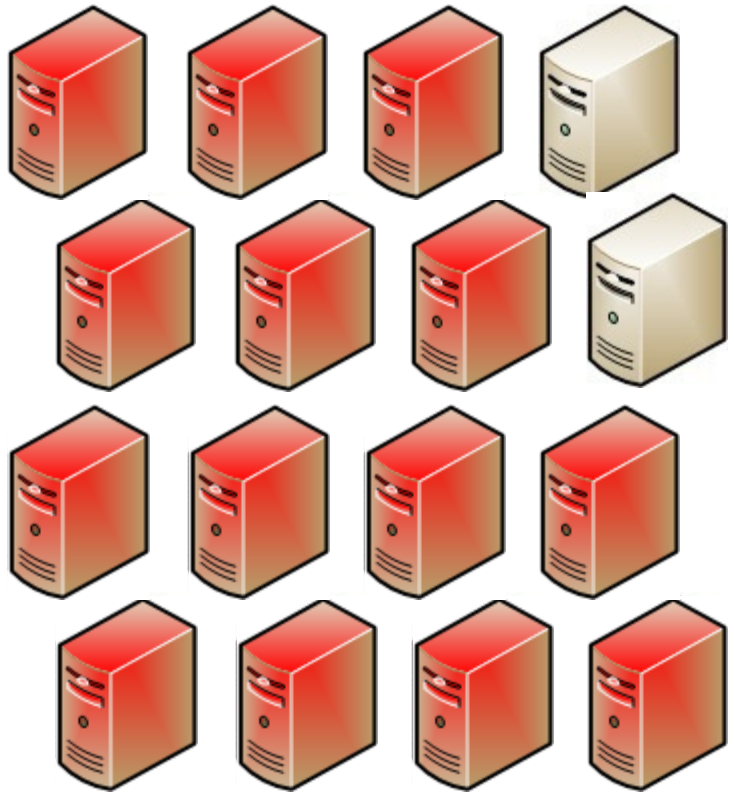
4:1 Virtualization



4 1U Servers @ 302W ea. Total 1.208kW → 1 Blade Server @ 195.25W → 4 Virtual Servers @ 48.8125W each

Dynamic Workload Management

- Server resources go from “always on” to “always available”
- As resources are needed, they are brought online
- As resources are no longer required, they are powered down or put in standby
- Saves energy



Network/Telecommunications

- Network must be “always on”
- Right-size
  - 100Mbps to desktop
  - Reevaluate VoIP phone selection
  - Carefully manage # of ports
- Consider ways to leverage network to improve environmental impact
- Use virtual connections for blade servers

Storage

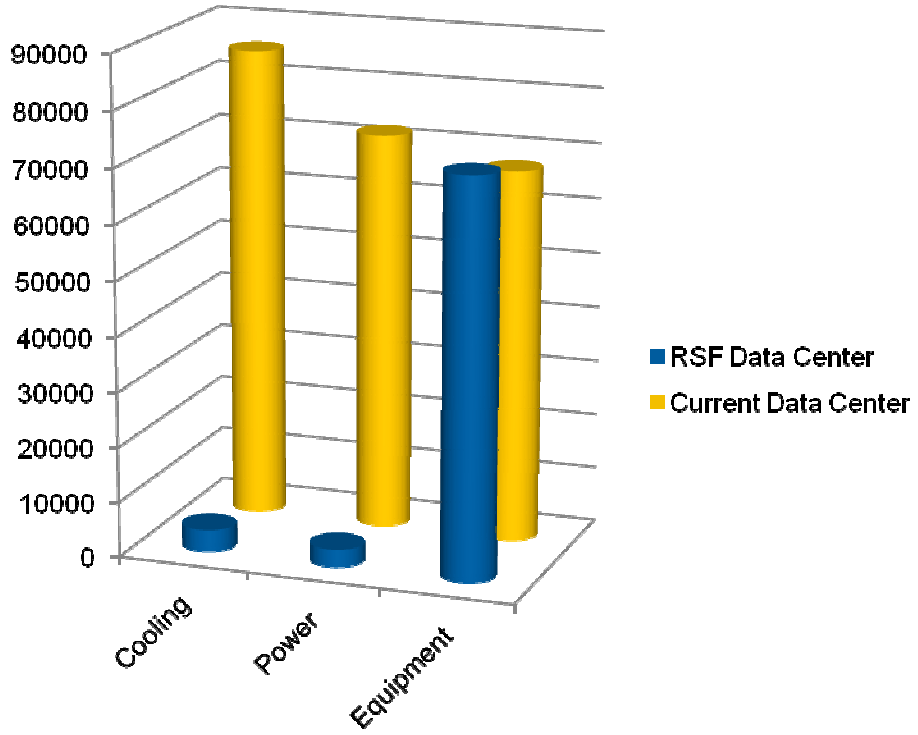
- Storage consolidation
- Thin provision
- Use data de-duplication and file compression
- Use appropriate RAID configuration
- Use largest disks possible
- Use tiered storage strategy

Current Data Center

- 30 years old
- 2,500 sq. ft.
- Supports corporate data center functions and HPC
- Challenged to support growing demands for space, power and cooling
- Inefficient power and cooling systems
- No backup generator power
- Performed energy audit to identify investments required to extend longevity
- Estimated PUE of 2.5

Expected Reduction in Data Center Power

- Target PUE of 1.1
- 65% overall reduction in data center power
- Equipment 30% more efficient
- Equipment load increased from lab growth and new capabilities



What does this mean?

- Better understand system requirements for projects
- Right-size systems
- Architect for scalability
- Make better use of existing system resources
- Turn off resources not in use
- Enhance capacity management processes
- Consider power costs in TCO for IT investments

Energy System Integration Facility (ESIF)

ESIF - Focus on renewable energy systems integration

- 130,000 g.s.f. building, ~200 staff
- Mixture of office and lab space

High Performance Computing

- 15,000 g.s.f. Data Center
- 2011: 200+ Tflops 1+ PByte storage
- 2014: 1+ Pflop
- Planning horizon 2010 to 2025.

ESIF: Data Center

Dual Mission:

Petascale system to meet NREL HPC computing needs, and

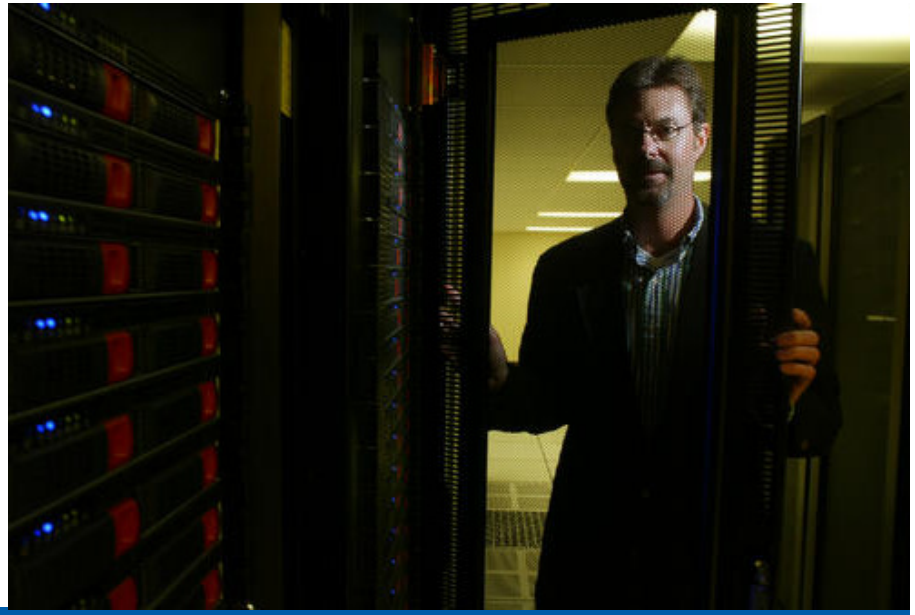
Showcase for data center energy efficiency.

Holistic view: integrate HPC equipment and a Data Center into an energy efficient building and campus.

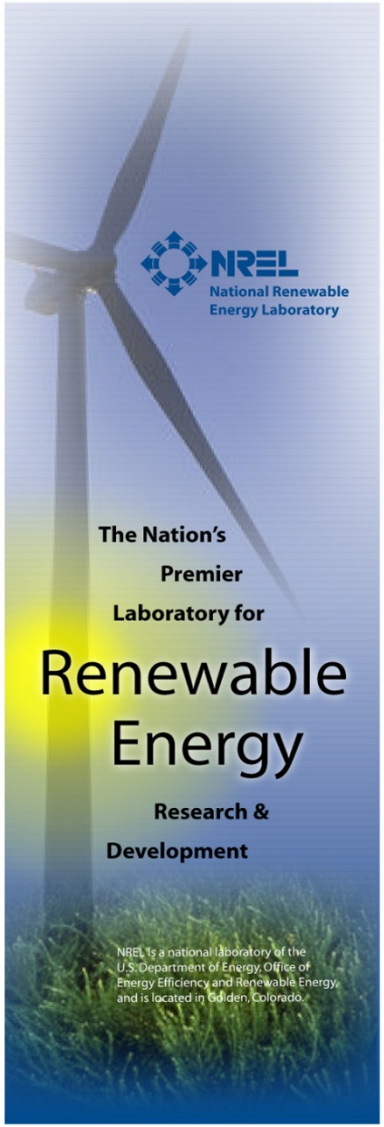
Integrate state-of-the-art technologies and design practices.

"Chips to Bricks" approach.

Unique opportunity with new construction.



Optimizing ESIF's Data Center Performance



- Seasonal PUE targets with fall, winter, spring PUE < 1!
- NO mechanical cooling or perimeter CRAC units
- Leverage favorable climate, evaporative cooling only
- Rely heavily on liquid cooling
- UPS exclusively for critical components
- Numerous waste heat utilization opportunities (pre-treat lab air, radiant heating in office space, snow melt, …)

- Monitor PUE (power usage effectiveness)
- PUE = Total Power / IT Equipment
- Economizer hours, temperature profiles, allowable conditions

- Dashboards to report instantaneous, seasonal and cumulative PUE values

Best Practices for Green Data Centers

- Use energy-efficient equipment
- Upgrade legacy equipment
- Consolidate & virtualize servers
- Right-size IT infrastructure
- Good relationship between IT and Facilities
- Track & manage data center energy consumption
- Perform long-term capacity planning for power
- Make energy consumption a part of TCO analysis
- Implement targeted/adaptive cooling solutions
- Improve airflow management

10 Things You Can Do Now to Make Your Data Center More Efficient

- Decommission obsolete equipment
- Perform regular maintenance on Computer Room Air Handlers
- Remove excess sub floor cabling and wiring
- Replace long power cords with shorter lengths to improve air flow
- Get rid of “rack spaghetti”, use wire management and ties to secure wiring
- Turn off the lights – install motion sensor switches if possible
- Cover all open rack spaces with blanking panels
- Use “Kool Loc” to cover floor openings and brush panels front mounted cable connections
- Configure your racks in a hot aisle/cold aisle
- Contain either hot aisle or cold aisle

The Green Workplace

Source: Corné de Graaf

Campus of the Future Prototype

NREL leased a LEED® certified building to house 128 IT staff

- The office environment
  - Low cube heights for light and air circulation
  - “huddle rooms” for privacy
- New technologies for collaboration
  - Idea paint – whiteboarding on the walls
  - Electronic white boards
  - Unified Communications
  - Headset
    - Computer, phone, mobile device
- Energy conservation
  - Replace printers/copiers/fax with all-in-one
  - Belt-high outlets for visual awareness
  - Personal refrigerators, microwaves and coffee pots not allowed
- Green recycling practices
  - Hardware
  - Recycle at 80 - simple trash

Culture Change

- Started with 80% resistance
  - Lack of privacy
  - Managers/Director do not have hard-walled offices
  - Loss of convenience
  - Separation from campus
- Currently less than 10% resistance
  - Several of most concerned are raving
  - Light lifts mood
  - Everyone has a window
  - The Walton's

Experiences will influence NREL's Campus of the Future


Feb '09

Desktop Environment

- Manage workstation lifecycle for environmental impact
- Use energy-efficient LCD monitors
- Use laptops with docking stations for road warriors & day extenders
- Evaluating the use of thin-client technology at the desktop

Workstation Type	Power	Reduction
Standard PC	400w	0%
Energy Star PC	300w	25%
Laptop	60w	85%
Thin Client	35w	91%

Technologies in Evaluation

- Application virtualization
- Thin clients
- Hot Desking
- Workstation Energy Measurement
- Virtual proximity
  - Microsoft Unified Communications
  - Round Table
  - Telepresence
- State-of-the-art conference rooms
  - Electronic whiteboards
  - Large monitors
  - Electronic room control

RSF Prototype

Henri Hubenka – Manager, Client Services

henri.hubenka@nrel.gov
(303) 275-4155

NREL Data Center

Contacts:

- **Chuck Powers**, Manager Information Technology Infrastructure and Operations
  chuck.powers@nrel.gov
  (303) 275-4182

- **Kevin Donovan**, Data Center Manager
  kevin.donovan@nrel.gov
  (303) 275-4169